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Exercises: Kc

Exercise #01

In a 2 L-container 4.0 g sulfur dioxide, 4.0 g oxygen and 20 g sulfur trioxide are at equilibrium. Determine the equilibrium constant Kc at that temperature for this reaction :

$$2\ SO_2\ (g) + O_2\ (g) \rightleftarrows 2\ SO_3\ (g)$$

Atomic Weights: S=32; O=16

Exercise #02

At 1000 K 1.03 mol/L nitrogen, 1.62 mol/L hydrogen and some amount of ammonia are at equilibrium. Determine the concentration of ammonia in this container, given the following data :

$$N_2\ (g) + 3\ H_2\ (g) \rightleftarrows 2\ NH_3\ (g) \qquad Kc = 2.38 * 10^{-3}\ L^2/mol^2$$

Exercise #03

In a 10 L-container the initial composition is 1 mol of phosphorus pentachloride. At a certain temperature, when the equilibrium is reached, only 0.3 mol of that compound is present. Determine the equilibrium constant for this reaction:

$$PCl_5\ (g) \rightleftarrows PCl_3\ (g) + Cl_2\ (g)$$

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Exercise #04

A 1-L vessel is charged initially with 80 g of sulfur trioxide. When equilibrium is reached at a certain temperature 0.6 mol of SO_2 are found inside. Determine the equilibrium constant, Kc, for this equation:

$$2\ SO_3\ (g) \rightleftarrows 2\ SO_2\ (g) + O_2\ (g)$$

Atomic Weights**: S=32; O=16**

Exercise #05

A intial composition in a 10 L-container is 104.39 g of hydrogen chloride and 2.00 g of hydrogen. When the equilibrium is reached, 1.30 mol of HCl are in the container. Determine the equilibrium constant for this reaction :

$$2\ HCl\ (g) \rightleftarrows H_2\ (g) + Cl_2\ (g)$$

M (HCl) = 36.5 g/mol; M(H_2) = 2 g/mol

Exercise #06

A 2 L-flask is charged with 0.10 mol of N_2O_4 and the equilibrium described below is reached. At this temperature the equilibrium constant is 0.58 mol/L. Determine the concentrations at equilibrium.

$$N_2O_4\ (g) \rightleftarrows 2\ NO_2\ (g)$$

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Exercise #07

A 2.3 L-container is initially charged with 0.0456 mol I_2. Determine the concentrations of both components at equilibrium if temperature is kept constant.

$$I_2\ (g) \rightleftarrows 2\ I\ (g) \qquad Kc = 3.8 * 10^{-5}$$

Exercise #08

At a certain temperature, the equilibrium constant Kc for the reaction below is 0.00793 mol/L. Determine the percentage of decomposition of PCl_5 at the same temperature if a 1 L-flask is charged initially 3.13 mol of PCl_5.

$$PCl_5\ (g) \rightleftarrows PCl_3\ (g) + Cl_2\ (g)$$

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Exercise #01

In a 2 L-container 4.0 g sulfur dioxide, 4.0 g oxygen and 20 g sulfur trioxide are at equilibrium. Determine the equilibrium constant Kc at that temperature for this reaction :

$$2\ SO_2\ (g) + O_2\ (g) \rightleftarrows 2\ SO_3\ (g)$$

Atomic Weights: S=32; O=16

The concentrations at equilibrium:

$$[SO_3] = \frac{n\ (SO_3)}{V} = \frac{20\ g}{2\ L}\ \frac{1\ mol}{80\ g} = 0.125\ M\ SO_3$$

$$[SO_2] = \frac{n\ (SO_2)}{V} = \frac{4\ g}{2\ L}\ \frac{1\ mol}{64\ g} = 0.03125\ M\ SO_2$$

$$[O_2] = \frac{n\ (O_2)}{V} = \frac{4\ g}{2\ L}\ \frac{1\ mol}{32\ g} = 0.0625\ M\ O_2$$

The value of Kc:

$$Kc = \frac{[SO_3]^2}{[SO_2]^2\ [O_2]} = \frac{(0.125\ M)^2}{(0.03125)^2\ (0.0625)} = 256\ \frac{L}{mol}$$

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Exercise #02

At 1000 K 1.03 mol/L nitrogen, 1.62 mol/L hydrogen and some amount of ammonia are at equilibrium. Determine the concentration of ammonia in this container, given the following data :

$$N_2\ (g) + 3\ H_2\ (g) \rightleftarrows 2\ NH_3\ (g) \qquad Kc = 2.38 * 10^{-3}\ L^2/mol^2$$

Substituting the values:

$$Kc = 2.38 * 10^{-3} = \frac{[NH_3]^2}{[H_2]\ [N_2]^3}$$

$$2.38 * 10^{-3} = \frac{[NH_3]^2}{(1.03\ M)\ (1.62\ M)^3}$$

$$[NH_3] = 0.102\ M$$

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Exercise #03

In a 10 L-container the initial composition is 1 mol of phosphorus pentachloride. At a certain temperature, when the equilibrium is reached, only 0.3 mol of that compound is present. Determine the equilibrium constant for this reaction:

$$PCl_5\ (g) \rightleftarrows PCl_3\ (g) + Cl_2\ (g)$$

The # of moles and concentrations at equilibrium:

$$PCl_5\ (g) \rightleftarrows PCl_3\ (g) + Cl_2\ (g)$$

n initial	1	0	0
n changes	-x	x	x
n equilibrium	1-x = 0.3	x = 0.7	x = 0.7
[ ] equilibrium	0.03 M	0.07 M	0.07 M

The equilibrium constant is:

$$Kc = \frac{[PCl_3]\ [Cl_2]}{[PCl_5]} = \frac{(0.07)^2}{(0.03)} = 0.163$$

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Exercise #04

A 1-L vessel is charged initially with 80 g of sulfur trioxide. When equilibrium is reached at a certain temperature 0.6 mol of SO_2 are found inside. Determine the equilibrium constant, Kc, for this equation:

$$2\,SO_3\,(g) \rightleftarrows 2\,SO_2\,(g) + O_2\,(g)$$

Atomic Weights**: S=32; O=16**

Molar mass of SO_3: $M(SO_3) = 32 + (3*16) = 80$ g/mol

The # of moles and concentrations at equilibrium:

$$2\,SO_3\,(g) \rightleftarrows 2\,SO_2\,(g) + O_2\,(g)$$

n initial	1	0	0
n changes	-2x	2x	x
n equilibrium	1-2x = 0.4	2x = 0.6	x = 0.3
[ ] equilibrium	0.4 M	0.6 M	0.3 M

The equilibrium constant is:

$$Kc = \frac{[SO_2]^2\ [O_2]}{[SO_3]^2} = \frac{(0.6)^2\ (0.3)}{(0.4)^2} = 0.675$$

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Exercises: Kc

Exercise #05

A intial composition in a 10 L-container is 104.39 g of hydrogen chloride and 2.00 g of hydrogen. When the equilibrium is reached, 1.30 mol of HCl are in the container. Determine the equilibrium constant for this reaction :

$$2\ HCl\ (g) \rightleftarrows H_2\ (g) + Cl_2\ (g)$$

M (HCl) = 36.5 g/mol; M(H_2) = 2 g/mol

Initial n: $n(HCl) = \dfrac{104.39\ g}{36.5\ g/mol} = 2.86\ mol\ HCl;\quad n(H_2) = 1\ mol\ H_2$

The # of moles and concentrations at equilibrium:

$$2\ HCl\ (g) \rightleftarrows H_2\ (g) + Cl_2\ (g)$$

n initial	2.86	1	0
n changes	-2x	x	x
n equilibrium	2.86-2x = 1.30	1+x = 1.78	x = 0.78
[ ] equilibrium	0.13 M	0.178 M	0.078 M

x=0.78

The equilibrium constant is:

$$Kc = \frac{[H_2]\ [Cl_2]}{[HCl]^2} = \frac{(0.178)\ (0.078)}{(0.13)^2} = 0.82$$

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Exercise #06

A 2 L-flask is charged with 0.10 mol of N_2O_4 and the equilibrium described below is reached. At this temperature the equilibrium constant is 0.58 mol/L. Determine the concentrations at equilibrium.

$$N_2O_4\ (g) \rightleftarrows 2\ NO_2\ (g)$$

The # of moles and concentrations at equilibrium:

$$N_2O_4\ (g) \rightleftarrows 2\ NO_2\ (g)$$

n initial	0.1	0
n changes	-x	2x
n equilibrium	0.1-x	2x
[ ] equilibrium	(0.1-x)/2	x

The equilibrium constant is: $$Kc = \frac{[NO_2]^2}{[N_2O_4]} = \frac{2x^2}{0.1 - x} = 0.58$$

The value of x has to be between 0 and 0.1: $2x^2 + 0.58\,x - 0.058 = 0 \rightarrow x = 0.07875$

The concentrations are:

$$[NO_2] = x = 0.07875\ M$$

$$[N_2O_4] = \frac{0.1 - x}{2} = 0.010625\ M$$

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Exercise #07

A 2.3 L-container is initially charged with 0.0456 mol I_2. Determine the concentrations of both components at equilibrium if temperature is kept constant.

$$I_2\ (g) \rightleftarrows 2\ I\ (g) \qquad Kc = 3.8 * 10^{-5}$$

The # of moles and concentrations at equilibrium:

$$I_2\ (g) \rightleftarrows 2\ I\ (g)$$

n initial	0.0456	0
n changes	-x	2x
n equilibrium	0.0456-x	2x
[ ] equilibrium	(0.0456-x)/2.3	0.87 x

From the equilibrium constant:

$$Kc = \frac{[I]^2}{[I_2]} = \frac{2.3 * (0.87\ x)^2}{0.0456 - x} = 3.8*10^{-5}$$

$$\rightarrow 1.74\ x^2 + 3.8*10^{-5}\ x - 1.73*10^{-6} = 0 \rightarrow x \simeq 0.001$$

$$[I] = 0.87\ x = 8.7 * 10^{-4}\ M$$

$$[I_2] = \frac{0.0456 - x}{2.3} = 1.94 * 10^{-2}\ M$$

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At a certain temperature, the equilibrium constant Kc for the reaction below is 0.00793 mol/L. Determine the percentage of decomposition of PCl_5 at the same temperature if a 1 L-flask is charged initially 3.13 mol of PCl_5.

$$PCl_5\ (g) \rightleftarrows PCl_3\ (g) + Cl_2\ (g)$$

The # of moles and concentrations at equilibrium:

$$PCl_5\ (g) \rightleftarrows PCl_3\ (g) + Cl_2\ (g)$$

n initial	3.13	0	0
n changes	-x	x	x
n equilibrium	3.13-x	x	x
[ ] equilibrium	3.13-x	x	x

From the equilibrium constant:

$$Kc = \frac{[Cl_2]\ [PCl_3]}{[PCl_5]} = \frac{x^2}{3.13 - x} = 7.93 * 10^{-3}$$

$$\rightarrow x^2 + 0.793 * 10^{-2}\ x - 2.48 * 10^{-2} = 0 \rightarrow x \simeq 0.161$$

$$d\ (\%) = \frac{x}{3.13} * 100 = 5\ \%$$